

2005 BUILDING ENERGY EFFICIENCY STANDARDS

CALIFORNIA
ENERGY
COMMISSION

COMMISSION CERTIFIED MANUAL



RESIDENTIAL COMPLIANCE MANUAL

CEC-400-2005-005-CMF
Revision 3

Arnold Schwarzenegger
Governor



4Q-05

Mike Chrisman

Secretary for Resources

CALIFORNIA ENERGY COMMISSION

William J. Keese
Chairman

Commissioners:

Arthur H. Rosenfeld
James D. Boyd
John L. Geesman
Jackalyne Pfannenstiel

Robert L. Therkelsen,
Executive Director

Valerie Hall,
Deputy Director
ENERGY EFFICIENCY and
DEMAND ANALYSIS DIVISION

Bill Pennington,
Office Manager
Buildings and Appliances Office

Project Manager
Maziar Shirakh, PE
Buildings and Appliances Office

Prepared by
Architectural Energy Consultants
San Francisco

Acknowledgements

Efficiency Standards Committees

Commissioner Jackalyne Pfannenstiel,
Presiding Member

Commissioner Arthur H. Rosenfeld, Ph.D.,
Associate Member

Principal Authors/Editors

The Residential Compliance Manual has evolved over the years with contributions made by many persons along the way. The 2005 Residential Compliance Manual was adapted from earlier versions in response to changes to the Standards made through the 2005 update. This most recent version was developed by Architectural Energy Corporation, with assistance from Jon McHugh of HMG. Charles Eley and Erik Kolderup of Architectural Energy Corporation were the technical editors. From the California Energy Commission, Maziar Shirakh, PE, was the project manager, as well as a contributor of technical content. Bill Pennington served as both the office manager and a technical contributor. Other technical contributors from the Energy Commission included Suzie Chan, John Eash, Gary Flamm, Elaine Hebert, Rob Hudler, Bruce Maeda, and Nelson Peña. Special thanks goes to Jon Leber, PE, for his invaluable and detailed comments on both the Residential and Nonresidential Compliance Manuals.

Technical contributors from Architectural Energy Corporation include Erik Kolderup and Charles Eley. Editing, layout and graphics were done by Zelaikha Akram, Tom Bergstrom, Kyra Epstein, and Kimberly Got.

Technical Assistance

The authors are grateful to many people and organizations that contributed to the development and production of this compliance manual. The manual reflects, to a large extent, the comments made by the many people who took time to carefully review earlier versions. Reviewers who contributed to the content include Gary Farber, Bill Mattinson and Mike Gabel of CABEC, Dee Anne Ross and Ken Nittler of Enercomp; Lynn Benningfield, Charles Ehrlich and Nehemiah Stone of the Heschong Mahone Group.

Lastly, so many others contributed helpful suggestions, comments and criticism that are impossible to show a complete list. However, their assistance is acknowledged and greatly appreciated.

In spite of all our efforts, omissions and errors are certain to occur. These, of course, are attributed to the authors alone. If a Manual user discovers an error or has a suggestion, we request that it be brought to the attention of the Energy Efficiency Hotline at 1-800-772-3300 (California) or 916-654-5106.

Acknowledgements	1
Efficiency Standards Committees.....	1
Principal Authors/Editors	1
Technical Assistance	1
1. Introduction	1-1
1.1 Related Documents	1-1
1.2 The Technical Chapters.....	1-2
1.3 Why California Needs Energy Efficiency Standards	1-3
1.4 What's New for 2005.....	1-7
1.5 Scope and Application	1-8
1.5.1 Building Types.....	1-8
1.5.2 Historical Buildings	1-11
1.5.3 Exempt Buildings.....	1-13
1.5.4 Building Systems Covered	1-14
1.5.5 Additions, Alterations and Repairs	1-14
1.6 Mandatory Measures and Compliance Approaches	1-18
1.6.1 Mandatory Measures.....	1-18
1.6.2 Prescriptive Packages.....	1-19
1.6.3 Performance Approach	1-19
1.7 Climate Zones.....	1-20
1.7.1 Building Location Data	1-21
1.8 Conditioned Floor Area	1-22
1.9 Where to Get Help	1-23
1.9.1 Energy Commission Publications and Support	1-23
1.9.2 Training Opportunities	1-25
1.9.3 Energy Consultants	1-25
1.9.4 On-Line Videos.....	1-25
1.9.5 HERS Raters and Providers.....	1-26
2. Compliance and Enforcement	2-1
2.1 Overview.....	2-1
2.2 Compliance and Enforcement Phases.....	2-1
2.2.1 Design Phase	2-2
2.2.2 Permit Application	2-2
2.2.3 Plan Check	2-3
2.2.4 Building Permit	2-3
2.2.5 Construction Phase	2-4
2.2.6 Building Department Field Inspection.....	2-4
2.2.7 Field Verification and/or Diagnostic Testing	2-5
2.2.8 Approval for Occupancy	2-5
2.2.9 Occupancy	2-6
2.3 Energy Standards Compliance Documentation	2-6
2.3.1 Building Permit Phase Documentation.....	2-7
2.3.2 Construction Phase Documentation (CF-6R).....	2-8
2.3.3 Field Verification and/or Diagnostic Testing Documentation (CF-4R).....	2-9
2.3.4 Homeowners Manual	2-10
2.4 Roles and Responsibilities.....	2-12
2.4.1 Designer	2-12
2.4.2 Documentation Author.....	2-13
2.4.3 Builder or General Contractor	2-13

2.4.4	Specialty Contractors	2-13
2.4.5	Building Department.....	2-14
2.4.6	HERS Provider.....	2-14
2.4.7	HERS Rater.....	2-15
2.4.8	Owner.....	2-15
2.5	Field Verification and/or Diagnostic Testing.....	2-17
2.5.1	Measures Requiring Field Verification and/or Diagnostic Testing	2-17
2.5.2	Sampling	2-18
2.5.3	For More Information	2-18
3.	Building Envelope Requirements	3-1
3.1	Overview	3-1
3.1.1	Introduction.....	3-1
3.1.2	Building Orientation	3-2
3.1.3	What's New for 2005	3-2
3.2	Fenestration.....	3-4
3.2.1	Relevant Sections in the Standards	3-4
3.2.2	Mandatory Measures.....	3-5
3.2.3	Prescriptive Requirements	3-12
3.2.4	Compliance Options	3-17
3.2.5	Compliance and Enforcement	3-24
3.3	Insulation.....	3-26
3.3.1	Insulation General Mandatory Measures	3-26
3.3.2	Ceiling/Roof Insulation	3-27
3.3.3	Radiant Barriers	3-34
3.3.4	Wall Insulation	3-35
3.3.5	Floor Insulation.....	3-41
3.3.6	Slab Insulation	3-44
3.3.7	Compliance Options	3-45
3.4	Thermal Mass	3-55
3.4.1	Mandatory Measures.....	3-56
3.4.2	Compliance Options	3-57
3.5	Infiltration and Air Leakage	3-58
3.5.1	Overview	3-58
3.5.2	Mandatory Measures.....	3-59
3.5.3	Compliance Options	3-62
3.6	Vapor Barriers and Moisture Protection.....	3-66
3.6.1	Mandatory Measures.....	3-66
3.7	Compliance and Enforcement.....	3-67
3.7.1	Design	3-68
3.7.2	Construction	3-68
3.7.3	Field Verification and/or Diagnostic Testing	3-69
3.8	Glossary/Reference	3-69
4.	Building HVAC Requirements	4-1
4.1	Overview	4-1
4.1.1	Introduction and Organization	4-1
4.1.2	Prescriptive Packages	4-1
4.1.3	Performance Method	4-2
4.1.4	What's New for 2005	4-2
4.1.5	Common System Types	4-3
4.1.6	Appliance Standards and Equipment Certification	4-3

Table of Contents	Page v
4.2 Heating Equipment	4-4
4.2.1 Mandatory Measures.....	4-4
4.2.2 Prescriptive Requirements	4-8
4.2.3 Compliance Options	4-8
4.3 Cooling Equipment.....	4-8
4.3.1 Mandatory Measures.....	4-8
4.3.2 Prescriptive Requirements	4-13
4.3.3 Compliance Options	4-15
4.4 Air Distribution Ducts and Plenums	4-16
4.4.1 Mandatory Measures.....	4-17
4.4.2 Prescriptive Requirements	4-23
4.4.3 Compliance Options	4-25
4.5 Controls.....	4-33
4.5.1 Setback Thermostats	4-33
4.5.2 Zonal Control.....	4-35
4.6 Alternative Systems	4-37
4.6.1 Hydronic Heating Systems	4-37
4.6.2 Radiant Floor System.....	4-41
4.6.3 Evaporative Cooling	4-44
4.6.4 Ground-Source Heat Pumps	4-45
4.6.5 Solar Space Heating	4-46
4.6.6 Wood Space Heating	4-46
4.6.7 Gas Appliances	4-49
4.7 Compliance and Enforcement.....	4-49
4.7.1 Design	4-49
4.7.2 Construction	4-50
4.7.3 Field Verification and/or Diagnostic Testing	4-50
4.8 Glossary/Reference	4-51
4.8.1 Refrigerant Charge Testing	4-51
5. Water Heating Requirements	5-1
5.1 Overview	5-1
5.1.1 Water Heating Energy	5-1
5.1.2 What's New for 2005	5-2
5.1.3 Water Heater Types	5-2
5.1.4 Distribution System Types.....	5-2
5.2 Mandatory Requirements.....	5-4
5.2.1 Equipment Certification	5-4
5.2.2 Equipment Efficiency.....	5-4
5.2.3 Pipe Insulation	5-6
5.2.4 Insulation Protection.....	5-8
5.2.5 Certification of Showerheads and Faucets	5-8
5.2.6 Storage Tank Insulation	5-8
5.2.7 Solar or Recovered Energy in State Buildings	5-8
5.2.8 Pool and Spa Equipment	5-9
5.3 Prescriptive Requirements.....	5-11
5.3.1 Pipe Insulation on Lines to Kitchen	5-11
5.3.2 Systems Serving Individual Dwelling Units	5-11
5.3.3 Systems Serving Multiple Dwelling Units	5-13
5.4 Compliance Options.....	5-15
5.4.1 Performance Compliance	5-15

5.4.2	Auxiliary Systems	5-15
5.4.3	Combined Hydronic.....	5-16
5.4.4	Distribution System Options	5-16
5.5	Compliance and Enforcement.....	5-17
5.5.1	Design	5-17
5.5.2	Construction	5-17
5.5.3	Field Verification and/or Diagnostic Testing	5-18
5.6	Glossary/Reference	5-18
5.6.1	Water Heater Types	5-19
5.6.2	Distribution Systems.....	5-20
6.	Lighting	6-1
6.1	Overview	6-1
6.1.1	Introduction and Scope	6-1
6.1.2	What's New for 2005	6-1
6.1.3	Related Documents	6-2
6.2	High Efficacy Luminaires	6-3
6.2.1	Lumens per Watt	6-4
6.2.2	Electronic Ballasts	6-5
6.2.3	Permanently Installed Luminaires	6-6
6.3	Kitchens	6-6
6.4	Bathrooms, Garages, Laundry Rooms and Utility Rooms	6-11
6.5	Other Rooms.....	6-12
6.6	Outdoor Lighting	6-14
6.7	Parking Lots and Parking Garages	6-15
6.8	Common Areas of Multifamily Buildings	6-16
6.9	Luminaires in Insulated Ceilings	6-16
6.10	Inspection Protocol for Recessed Luminaires in Insulated Ceilings	6-17
6.11	Recommendations for Luminaire Specifications.....	6-20
6.12	Residential Manual-On Occupant Sensors.....	6-20
6.13	Residential Dimmers	6-22
7.	Performance Method	7-1
7.1	Overview	7-1
7.2	What's New for 2005.....	7-3
7.3	The Process.....	7-3
7.3.1	Defining the Standard Design	7-4
7.3.2	Standard Reports	7-5
7.3.3	Professional Judgment.....	7-7
7.4	Mixed Occupancy Buildings.....	7-7
7.5	Multifamily Buildings	7-8
7.5.1	Whole Building Compliance	7-8
7.5.2	Compliance Unit-By-Unit	7-9
7.6	Subdivisions And Master Plans	7-10
7.6.1	Individual Building Approach	7-10
7.6.2	Multiple Orientation Alternative: No Orientation Restrictions	7-11
7.7	HVAC Issues.....	7-12
7.7.1	No Cooling Installed	7-12
7.7.2	Equipment without SEER	7-12
7.7.3	Multiple HVAC Systems	7-12
7.7.4	Gas-Fired Cooling Systems	7-13
7.7.5	Cool Roofs.....	7-13

7.7.6 Existing + Addition + Alteration Approach	7-13
8. Additions, Alterations and Repairs	8-1
8.1 Introduction	8-1
8.2 Compliance Approaches	8-4
8.3 Building Envelope	8-5
8.3.1 Mandatory Requirements	8-5
8.3.2 Prescriptive Requirements for Additions Alone	8-6
8.3.3 Prescriptive Requirements for Alterations	8-9
8.4 HVAC	8-12
8.4.1 Mandatory Requirements	8-12
8.4.2 Prescriptive Requirements	8-13
8.5 Water Heating	8-20
8.5.1 Replacement Water Heaters	8-20
8.5.2 Additions	8-21
8.6 Lighting	8-23
8.7 Performance Method for Additions and Alterations	8-24
8.7.1 Whole Building Approach	8-24
8.7.2 Addition Alone Approach	8-25
8.7.3 Existing + Addition + Alteration Approach (also applies to Existing + Alteration when there is no Addition)	8-26
9. INDEX	9-1
Appendix A Compliance Forms.....	A-1
Appendix B Applicable Tables and Language from Standards and RACM	B-1
2005 Building Energy Efficiency Standards Table 116-A and Table 116-B.....	B-1
Section 118 (d) and 118 (e).....	B-3
Section 150 (a) and 150 (b)	B-4
Table 151-B and Table 151-C	B-5
Section 152 (a) and 152 (b)	B-8
2005 Residential ACM Manual Table R-3-11	B-12
Appliance Efficiency Standards Table F-3 and Table F-4	B-13
Appendix C Natural Gas Appliance Testing (NGAT) Standards.....	C-1
Appendix D Eligibility Criteria for Radiant Barriers.....	D-1

List of Tables

Table 1-1 – Compliance Options vs. Design Recommendations	1-3
Table 1-2 – Building Types Covered by the Low-Rise Residential and Nonresidential Standards	1-10
Table 1-3 – Energy Commission Video Series Titles.....	1-27
Table 2-1 – Documentation Requirements, Prescriptive and Performance Compliance Methods	2-6
Table 3-1 – Allowable Methods for Determining U-factors	3-8
Table 3-2 – Methods for Determining Solar Heat Gain Coefficients	3-8
Table 3-3 – Maximum U-factors by Climate Zone in Packages C and D	3-14
Table 3-4 – Package C and D SHGC Criteria by Climate Zone	3-16
Table 3-5 – Qualifying Exterior Shades and Solar Heat Gain Coefficients	3-22
Table 3-6 – Raised Floor Constructions Used as Basis for Equivalent U-factor Compliance	3-42
Table 4-2 – Minimum Heating Efficiency for Non-Ducted, Non-Central Gas Fired Heating Equipment	4-5

	Table 4-3 – Minimum Heating Efficiency for Heat Pumps	4-6
	Table 4-4 – Minimum cooling Efficiencies for Central Air Conditioners and Heat Pumps.....	4-9
	Table 4-5 – Minimum Cooling Efficiency for Larger Central Air Conditioners and Heat Pumps	4-9
	Table 4-6 – Minimum Cooling Efficiency for Non-Central Space Cooling Equipment Including Room Air Conditioners; and Room Air Conditioner Heat Pumps; Package Terminal Air Conditioners (PTAC); Package Terminal Heat Pumps (PTHP);	4-10
	Table 4-7 – Alternatives to Duct Sealing and Refrigerant Charge Measurement in New Construction Package D only (gas heat or heat pump space heating).....	4-15
	Table 4-8 – Slab Insulation Requirements for Heated Slabs	4-42
	Table 4-9 – Standards for Ground Water-Source and Ground-Source Heat Pumps Manufactured on or after October 29, 2003	4-45
	Table 4-10 – Minimum Air Movement Requirements for Evaporative Coolers	4-45
	Table 4-11 – Structure of Target Superheat Temperature.....	4-54
	Table 4-12 – Structure of Target Temperature Split (Return Dry-Bulb minus Supply Dry-Bulb)....	4-54
	Table 5-1 – System Component Descriptions: Distribution Systems within a Dwelling Unit.....	5-3
	Table 5-2 – Minimum Energy Factor Small Water Heaters	5-5
	Table 5-3 – Framing Percentages	5-6
	Table 5-4 – Preapproved Alternative Water Heating Systems for Single Dwelling Units (Equivalent to prescriptive requirement).....	5-12
	Table 6-1 – High Efficacy Lamps	6-4
	Table 7-1 – Special Features to be Listed on CF-1R.....	7-6
	Table 8-1 – Comparison of Compliance Methods for Additions.....	8-5
	Table 8-2 – Prescriptive Envelope Requirements for Additions.....	8-7
	Table 8-3 – Alternatives to Duct Sealing and Refrigerant Charge Measurement	8-16
	Table 8-4 – Acceptable Replacement Heating System Fuel Source(s).....	8-17

List of Figures

Figure 1-1 – One Year Low-Rise Residential Electricity Reduction Due to the 2005 Standards	1-4
Figure 1-2 – One Year Low-Rise Residential Electric Demand Reduction Due to the 2005 Standards	1-4
Figure 1-3 – Gas Reduction Due to the 2005 Standards	1-5
Figure 1-4 – California Climate Zones	1-21
Figure 1-5 – Total Conditioned Floor Area.....	1-22
Figure 1-6 – Energy Commission Blueprint Newsletter	1-24
Figure 1-7 – Energy Commission Video Series	1-26
Figure 3-1 – NFRC Temporary Label	3-7
Figure 3-2 – Package D Prescriptive Fenestration U-factor Limits by Climate Zone	3-14
Figure 3-3 – Package C and D SHGC Criteria by Climate Zone	3-15
Figure 3-4 – Package C and D Prescriptive West-Facing Window Area Limits by Climate Zone...	3-17
Figure 3-5 – Glass Area in Single Family and Multifamily Residence.....	3-18
Figure 3-6 – Difficulty of Shading East- and West-Facing Windows	3-20
Figure 3-7 – South-Facing Overhang Dimensions for Prescriptive Compliance.....	3-21
Figure 3-8 – Package D Prescriptive Ceiling/Roof Insulation Requirements	3-29
Figure 3-9 – Ceiling Insulation Construction Detail	3-31
Figure 3-10 – Baffles at the Eave in Attics	3-31
Figure 3-11 – IC-Rated Light Fixture	3-33
Figure 3-12 – Methods of Installation for Radiant Barriers	3-34
Figure 3-13 – Package D Wall Requirements by Climate Zone	3-36
Figure 3-14 – Brick Wall Construction Details	3-38
Figure 3-15 – Wall Construction Detail	3-39
Figure 3-16 – Raised Floor Insulation Requirements by Climate Zone	3-41

Figure 3-18 – Allowed Slab Edge Insulation Placement	3-45
Figure 3-19 – Examples of Poor Quality Insulation Installation	3-47
Figure 3-20 – Cellulose Insulated Wall	3-48
Figure 3-21 – Methods of Joining SIPS Panels	3-53
Figure 3-22 – Controlled Ventilation Crawl Space	3-53
Figure 3-23 – Thermal Mass Performance	3-56
Figure 3-24 – Caulking and Weatherstripping	3-60
Figure 3-25 – Fireplace Installation.....	3-61
Figure 3-26 – Air-Retarding Wrap.....	3-64
Figure 3-27 – Blower Door Testing	3-65
Figure 3-28 – Vapor Barriers with Kraft Paper.	3-67
Figure 4-1 – Outdoor Compressor/Condenser Unit	4-11
Figure 4-2 – Refrigerant Line Insulation.....	4-12
Figure 4-3 – Checking Refrigerant Charge	4-14
Figure 4-4 – R-4.2, R-6, and R-8 Ducts	4-24
Figure 4-5 – Example: Buried Ducts on Ceiling and Deeply Buried Ducts	4-26
Figure 4-6 – Connecting Round Metallic Ducts	4-28
Figure 4-7 – Connecting Flex Ducts Using Mastic and Mesh	4-28
Figure 4-8 –Connecting Flex Ducts Using Tape and Clamps	4-29
Figure 4-9 – Sealing Metallic Ducts with Mastic and Mesh.....	4-30
Figure 4-10 – Options for Suspending Rigid Round Metal Ducts	4-30
Figure 4-11 – Options for Suspending Rectangular Metal Ducts.....	4-31
Figure 4-12 – Minimum Spacing for Suspended Flex Ducts.....	4-31
Figure 4-13 – Minimum Spacing for Supporting Vertical Flex Ducts	4-32
Figure 4-14 – Minimizing Radius for Flex Duct Bends	4-32
Figure 4-15 – Computer-Controlled Aerosol Injection System.....	4-33
Figure 4-16 – Zonal Control Example	4-36
Figure 4-17 – Hydronic Heating System Components.....	4-39
Figure 4-18– Combined Hydronic System with Water Heater as Heat Source.....	4-39
Figure 4-19 – Combined Hydronic System with Boiler and Indirect Fired Water Heater	4-41
Figure 4-20– Heated Slab-On-Grade Floor Insulation Options.....	4-43
Figure 4-21 – Benefit of Thermostatic Expansion Valve	4-51
Figure 4-22 – Measurement Locations for Refrigerant Charge and Airflow Tests	4-53
Figure 5-1 – Meeting Pipe Insulation Requirements for Storage Tank Water Heaters	5-7
Figure 5-2 – Point of Use Distribution System	5-22
Figure 6-1 – Typical Lamp Efficacies	6-5
Figure 6-2 – Kitchen Work Surface Lighting	6-7
Figure 6-3 – General Kitchen Lighting	6-8
Figure 6-4 – Airtight, Type IC Luminaire	6-17
Figure 7-1– Multifamily Building Compliance Option	7-9
Figure 7-2– Subdivisions and Master Plans Compliance Option	7-11
Figure 8-1 – Addition Alone Prescriptive Compliance Approach	8-8
Figure 8-2 – Addition Alone Performance Compliance Approach	8-25